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CLINICAL STUDY

Blood pressure impact on left ventricular geometry in chronic haemodialysis patients

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Abstract: *Aim:* Left ventricular hypertrophy in chronic haemodialysis patients is multifactorial. Our aim was to evaluate retrospectively the relationship between 24-h blood pressure monitoring and geometry and function of left ventricle (LV).
Patients a methods: We examined 50 patients (men/women 33/17) treated by chronic haemodialysis (>3 months) aged 57.5 years (53–63; median, interquartile range). We measured blood pressure during 24 hours in short interdialytic period using Spacelab monitor 90217. Echocardiography was provided in short interdialytic period.
Results: Left ventricular mass index significantly correlated with SBP (tau-b=0.21; p=0.030; 95%CI 0.01–0.42), DBP (tau-b=0.23; p=0.018; 95%CI 0.04–0.42) and MAP (tau-b =0.26; p=0.009; 95%CI 0.06–0.45). SBP, DBP, MAP and PP did add a significant information to the prediction of relative wall thickness. We did not find any relationship between BP and left ventricular ejection fraction, left ventricular enddiastolic diameter and left atrial size.
Conclusion: We found out an important 24-hour blood pressure impact on left ventricular relative wall thickness and left ventricular mass index. Left ventricular ejection fraction, left ventricular enddiastolic diameter and left atrial size were not related to 24-hour blood pressure. We did not find a relationship between blood pressure and left ventricular enddiastolic diameter. From all diastolic parameters the strongest association was found between systolic blood pressure in all three phases and ratio of peak early to late diastolic filling velocity *(Tab. 5, Ref. 19)*. Full Text in PDF *www.elis.sk.*
Key words: myocardial hypertrophy, haemodialysis, 24-hour ambulatory blood pressure monitoring.

Cardiovascular complications of haemodialysis treatment are the most common cause of increased morbidity and mortality among these patients (1). Already stage 3 chronic kidney disease patients with glomerular filtration rate <60 ml/min/1.73m^2 belongs to the high cardiovascular risk group (2). Echocardiography verified left ventricular concentric or excentric hypertrophy is present at the beginning of haemodialysis treatment in 50–75 %, while during the next course the amount is further increasing (3). Uremic cardiomyopathy is a term used in connection with disturbed left ventricular morphology and funtion in renal failure. It is a myocardial dysfunction, which occured due to long lasting impact of hemodynamic and non-hemodynamic, with uraemia and dialysis associated risk factors. Arterial hypertension, volume overload, anaemia, uremic toxins, hyperparathyroidism and increased sympathetic activity belong to the most dominant risk factors (4). A strong relationship between left ventricular (LV) mass and blood pressure was shown also in a non-uraemic population. To confirm this relationship in haemodialysis patients is more difficult due to many factors affecting LV mass. Blood pressure values obtained by ambulatory or home blood pressure monitoring provide more prognostic information on cardiovascular risk compared to blood pressure values measured during haemodialysis (5, 6).

Aim of the retrospective study was to evaluate the impact of blood pressure measured by 24-hour ambulatory blood pressure monitoring (24-h ABPM) on LV geometry and function in chronic haemodialysis patients.

Patients and methods

We examined 50 patients (men/women 33/17) treated by chronic haemodialysis (>3 months) aged 57.5 years (53–63; median, interquartile range). All patients were dialysed thrice weekly and signed an informed consent with investigation. No incidence of hemodynamic instability event occured during haemodialysis.

Parameters of haemodialysis

A bicarbonate – buffered dialysate was used. Temperature of dialysate solute reached 37–38 °C and it‘s reduction was not needed in any of the patients¸ natrium concentration reached 138 mmol/l (supraphysiologic concentration and profiled ultrafiltration were not necessary to apply). The dialysate solute type with potassium and calcium concentrations were used in accordance

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with actual monthly blood tests results in which 24-h ABPM was provided. Potassium concentration in dialysate solute reached 2 or 3 mmol/l and calcium 1.5 or 1.75 mmol/l.

24-hour ambulatory blood pressure monitoring

The Spacelab monitor 90217 and appropriate arm cuff was applied on a non-access upper arm after the HD session ended. In every patient a routine daily activities were noticed during the measurement, which were carried out every 20 minutes during the daytime (6 a.m. – 10 p.m.) and every 40 minutes during the nighttime (10 p.m. – 6 a.m.). Inclusion criteria: minimum 70 % of successful readings, minimum 14 daytime and 7 night time measurements. From 55 examined patients 5 did not fulfill the conditions and were excluded. Our analysed group contained 50 patients. Basic laboratory parameters were examined and used for analysis during routine monthly blood test control in which 24-h ABPM was provided. Antihypertensive treatment was used in 45 (90 %) patients.

Echocardiography examination

Echocardiography was performed using an ultrasound machine VIVID 3 PRO from company General Electrics, USA. All patients underwent examination always during an interdialytic day according to the standard protocol and recommendations of ASE(American Society of Echocardiography) (7).The following measurements were obtained from M mode in projection on long parasternal axis: interventricular septum enddiastolic thickness (IVSd), posterior wall thickness (PWd) and left ventricular enddiastolic diameter (LVEDD). Left atrial diameter (LA) was measured in the same projection at the end of diastole. Left ventricular ejection fraction (EF) was obtained according to Simpson in 4-chamber apical projection. Left ventricular mass (LVM) was calculated according to ASE (7):

$$LVM\ (g) = 0.8\ .\ 1.04\ .\ [(IVSd + LVEDD + PWd)^3 - LVEDD^3] + 0.6g$$ (values IVSd, LVEDD, PWd v mm)

Left ventricular mass index (LVMI) was derived from formula: LVM/body surface area (BSA). LVMI ≤125 g/m^2 and in women ≤110 g/m^2 was taken as evidence of normal finding (8).

Left ventricular relative wall thickness (RT) was defined as: (IVSd + PWd/LVEDD). The values of RT ≤0.44 in both genders were considered as normal.

- normal geometry (normal RT, normal LVMI)
- concentric remodelation (increase RT, normal LVMI)
- excentric hypertrophy (normal RT, increase LVMI)
- concentric hypertrophy (increase RT, increase LVMI)

Parameters of left ventricular diastolic function were measured in 42 patients with sinus rhythm according to transmitral flow: peak velocity of early diastolic filling (E), peak velocity of late diastolic filling (A), ratio of peak early to late diastolic filling velocity (E/A), deceleration time (DCT) and isovolumic relaxation time (IVRT). In 8 patients left ventricular diastolic function parameters were not obtained due to the presence of atrial fibrilation.

Statistical analyses

Each analysed parameter was examined for normality (The Shapiro–Wilk W test and graphical examination), abnormally distributed parameters are presented as median and interquartile range. Pearson correlation coefficients were calculated to determine the correlations between the clinical characteristics. In the presence of outliers, detected by graphical examination, Kendall's tau b coefficient was used. A p-value <0.05 was considered statistically significant. All presented p values are two-sided. Statistical analyses were performed using Stats Direct statistical package version 2.7.8 (Stats Direct Ltd. http://www.statsdirect.com)

Results

Our group contains 50 chronic haemodialysis patients (33 men and 17 women), average age 57.5 (53–63) years. Average length of dialysis reached 15 (7–54) months. The most common reasons of renal failure were following: diabetes mellitus (34 %), tubulointersticial nephritis (24 %), glomerulonephritis (20 %) and arterial hypertension (12 %). Basic characteristics and laboratory data of our group are shown in Table 1. Usage of antihypertensive treatment in our group was following: inhibitors of angiotensin-converting enzyme (44 %) and AT1 receptors (26 %), calcium channel blockers (62 %), beta blockers (56 %), central antihypertensive drugs (48 %). Loop diuretics were used in 20 patients (40 %) with residual renal function.

Average blood pressure data during 24-hours ABPM are represented in Table 2. There were no important differences between 24

Tab. 1. Characteristics of chronic haemodialysis (HD) patients.

Total (men/women)	50 (33/17)
Age (years)	57.5(53–63)
Body mass index (kg/m^2)	24.5(22.1–28.5)
HD duration (months)	15(7–54)
Index of HD adequacy – Kt/V	1.4(1.2–1.5)
Total ultrafiltration (ml)	3375(2500–4275)
Hemoglobin (g/l)	111(104–116)
Hematocrit	0.33(0.31–0.35)
S-natrium (mmol/l)	138(136–140)
S- kalium (mmol/l)	4.9(4.7–5.5)
S-calcium (mmol/l)	2.3(2.2–2.4)
S-phosphorus (mmol/l)	1.7(1.3–2.3)
S-parathormon (pmol/l)	14.4(8.2–26)
S-cholesterol (mmol/l)	4.7(3.9–5.2)
S-creatinine before HD (μmol/l)	783(674–904)
S-urea before HD (mmol/l)	22.7(17.8–25.8)
S-urea after HD (mmol/l)	5.2(4.2–6.5)

Data are expressed as medians (interquartile range)

Tab. 2. Blood pressure values obtained by 24-hour monitoring during interdialytic period.

	24 hours	Daytime	Nighttime
Systolic pressure (mmHg)	129 (113–150)	130 (120–150)	122 (109–143)
Diastolic pressure (mmHg)	77 (67–86)	78 (72–86) [a]	74 (64–80)
Mean arterial pressure (mmHg)	96 (85–108)	97 (91–109) [b]	90 (89–102)
Pulse pressure (mmHg)	51 (38–66)	53 (41–66) [c]	45 (37–58)

[a] – diastolic blood pressure: daytime versus nighttime p=0.010, [b] – mean arterial blood pressure: daytime versus nighttime p=0.030, [c] – pulse pressure: daytime versus nighttime p=0.050. Data are expressed as medians (interquartile range).

Tab. 3. Echocardiographic data in chronic haemodialysis patients.

	Median (interquartile range)
LV ejection fraction (%)	60 (54–62)
LV mass (g)	262 (225–315)
LV mass index (g/m2)	140 (117–161)
Left atrium size (mm)	44 (39–47)
LV end diastolic diameter (mm)	48 (44–53)
LV relative wall thickness (mm)	0,5 (0,4–0,6)
Peak velocity of early diastolic filling (E, m/s)	0,73(0,60–0,97)
Peak velocity of late diastolic filling (A, m/s)	0,90 (0,79–1,00)
Ratio E/A	0,77 (0,61–1,13)
Deceleration time (ms)	180 (170–214)
Isovolumic relaxation time (ms)	90 (80–100)

LV – left ventricular. Data are expressed as medians (interquartile range).

hours, daytime and nighttime values in systolic pressure and only marginally significant difference between dayime and nighttime in pulse pressure (p=0.050) was found. For diastolic (p=0.010) and mean arterial blood pressure (p=0.030) pressure significant difference between daytime and nighttime was confirmed.

Successful readings reached 86 (74–93%); reported as median (interquartile range). Echocardiographic parameters are shown in Table 3. Left ventricular diastolic function parameters were obtained from 42 patients with sinus rhythm.

Normal left ventricular geometry was found only in 5 patients (10 %), concentric remodelation in 12 patients (24 %), concentric hypertrophy in 25 patients (50 %) and excentric hypertrophy in 8 patients (16 %). Left ventricular geometric types (concentric and excentric hypertrophy, concentric remodelation) were not related to blood pressure (SBP, DBP, MAP and PP).

Relationships between echocardiographic parameters and blood pressure values during 24-hours ABPM in interdialytic period are detailed in Table 4.

LVMI showed significant relationship to SBP in all three phases of blood pressure monitoring (24 hours: tau-b=0.21; p=0.030; 95%CI 0.01–0.42; day: tau-b=0.25; p=0.011; 95%CI 0.05–0.45; night: tau-b=0.19; p=0.048; 95%CI –0.40–0.01); DBP (24 hours: tau-b=0.23; p=0.018; 95%CI 0.04–0.42 and day: tau-b=0.24; p=0.015; 95%CI 0.05–0.43 and trend toward significancy for night: r=0.17; p=0.070; 95%CI –0.02–0.37); MAP in all three blood pressure monitoring phases (for 24hours: tau-b=0.26; p=0.009; 95%CI 0.06–0.45 and day: tau-b=0.26; p=0.009; 95%CI 0.06–0.44; night: tau-b=0.22; p=0.030; 95%CI 0.01–0.42) and PP (day: r=0.20; p=0.040; 95%CI 0.05–0.55).

SBP, DBP, MAP and PP did add a significant information to the prediction of relative wall thickness. A significant information was added to the prediction of relative wall thickness and SBP (for 24 hour: r=0.54; p=0.001; 95= CI 0.31–0.71; day: r= 0.54; p=0.001; 95%CI 0.31–0.71 and night: r=0.50; p=0002 ; 95%CI 0.27–0.69), DBP (for 24 hour: r=0.53; p=0.001; 95%CI 0.29–0.70; day:r=0.54; p=0.001; 95%CI 0.30–0.71 and night:r=0.48; p=0.004; 95%CI 0.25–0.67), MAP (for 24 hour: r=0.54; p=0.001; 95%CI 0.31–0.71; day:r=0.001; p=0.54; 95%CI 0.31–0.71 and night: r= 0.50; p=0.002; 95%CI 0.26–0.69) and PP only for 24 hour (r=0.30; p=0.030; 95%CI 0.03–0.54) and day (r=0.33; p=0.018; 95%CI 0.05–0.55).We did not find any connection between BP and left ventricular ejection fraction, left ventricular end diastolic diameter and left atrial size.

From all diastolic parameters (Tab. 5) statistically significant relationship was shown only in ratio of peak early to late diastolic filling velocity and SBP for 24 hours (r=0.32; p=0.03; 95%CI 0.02–0.6) and day (r=0.33; p=0.03; 95%CI 0.03–0.6) and marginally for night (p=0.05; r=0.30; 95% -0.01-0.55). Relationship between isovolumic relaxation time and PP was significant during the night (r=-0.33; p=0.030; 95%CI –0.5 to –0.03) and borderline significance for night DBP (tau=-0.20; p=0.070; 95%CI –0.6–0.0) and MAP during the day (tau=-0.21; p=0.06; 95%CI –0.6–0.0).

Although some of the weak correlations, which were found, cannot be considered statistically conclusive, the borderline prob-

Tab. 4. Relationship between left ventricular geometric parameters and blood pressure values during 24-hour ambulatory monitoring in interdialytic period.

	RT			LA	LVMI			EF	LVEDD
	p	r	(95% CI)		p	tau-b	(95% CI)		
Systolic pressure									
24 hours	0.001	0.54	(0.31–0.71)	NS	0.030	0.21	(0.01–0.42)	NS	NS
Daytime	0.001	0.54	(0.31–0.71)	NS	0.011	0.11	(0.05–0.45)	NS	NS
Nighttime	0.002	0.50	(0.27–0.69)	NS	0.048	0.19	(-0.40–0.01)	NS	NS
Diastolic pressure									
24 hours	0.001	0.53	(0.29–0.70)	NS	0.018	0.23	(0.04–0.42)	NS	NS
Daytime	0.001	0.54	(0.30–0.71)	NS	0.014	0.24	(0.05–0.43)	NS	NS
Nighttime	0.004	0.48	(0.23–0.67)	NS	NS			NS	NS
Mean arterial pressure									
24 hours	0.001	0.54	(0.31–0.71)	NS	0.009	0.26	(0.06–0.45)	NS	NS
Daytime	0.001	0.54	(0.31–0.71)	NS	0.009	0.26	(0.06–0.44)	NS	NS
Nighttime	0.002	0.50	(0.26–0.69)	NS	0.030	0.22	(0.01–0.42)	NS	NS
Pulse pressure									
24 hours	0.030	0.30	(0.03–0.54)	NS	NS			NS	NS
Daytime	0.018	0.33	(0.05–0.55)	NS	0.040	0.20	(0.02–0.38)	NS	NS
Nighttime	NS			NS	NS			NS	NS

RT – left ventricular relative wall thickness, LA – left atrial size. LVMI – left ventricular mass index, EF – left ventricular ejection fraction, LVEDD – left ventricular end-diastolic diameter, r – correlation coeficient, tau – Kendall tau – b coefficient, NS – statistically not significant difference; 95% CI – confidence interval

Tab. 5. Relationship between the parameters of left ventricular diastolic function and blood pressure values during 24-hour ambulatory monitoring in interdialytic period.

	E	A	E/A			DCT	IVRT		
			p-value	r	(95%CI)		p-value	r	(95%CI)
Systolic pressure									
24 hours	NS	NS	0.03	0.3	(0.02–0.6)	NS		NS	
Daytime	NS	NS	0.03	0.3	(0.03–0.6)	NS		NS	
Nighttime	NS	NS	0.05	0.3	(-0.01–0.6)	NS		NS	
Diastolic pressure									
24 hours	NS	NS		NS		NS		NS	
Daytime	NS	NS		NS		NS		NS	
Nighttime	NS	NS		NS		NS		NS	
Mean arterial pressure									
24 hours	NS	NS		NS		NS		NS	
Daytime	NS	NS		NS		NS		NS	
Nighttime	NS	NS		NS		NS		NS	
Pulse pressure									
24 hours	NS	NS		NS		NS		NS	
Daytime	NS	NS		NS		NS		NS	
Nighttime	NS	NS		NS		NS	0.03	-0.03	(-0.5– -0.03)

E – peak velocity of early diastolic filling, A – peak velocity of late diastolic filling, E/A – ratio of peak early to late diastolic filling velocity, DCT – deceleration time, IVRT – isovolumic relaxation time, P – Pearsonov koeficient, r – korelačný koeficient; tau b – Kendall´s coefficient; CI – confidence interval; NS – statistically not significant difference

ability values and common traits underlying these factors make the associations highly probable.

Antihypertensive treatment was intensificated according to 24-h ABPM results in 16 patients (32 %). We confirmed high cardiovascular morbidity and mortality, although it was not a primary endpoint. 12 patients (24 %) with average age 60 (53–67.5) years died during our 14 month follow-up study. Half of them were diabetics and the length of surveillance reached 53 (22–61) months. Cardiovascular cause of death was confirmed in 8 patients, sepsis in 2 patients and oncological disease in 2 patients.

Discussion

There were 90 % patients with abnormal and only 10 % with normal myocardial geometry in our study group. Other studies also confirmed this finding (9, 10). Relationship between left ventricular geometric types (concentric and excentric hypertrophy, concentric remodelation) and blood pressure had no predictive power. We suppose multifactorial impact on left ventricular geometry in which circulating blood volume plays the main role (11). In agreement with other authors we confirmed the relation of LVMI, RT and blood pressure (SBP, DBP and MAP and partially PP) during 24 hours – diurnal confirmation (12, 13).

Correlation between LVMI and SBP, DBP, MAP and PP shows an unfavourable pathogenetic impact of increased blood pressure on the left ventricle. Hampl et al (14) confirmed significant reduction of LVMI, LVEDD and ejection fraction increase, but no left atrial size decrease in a group of 230 patients due to intensificated antihypertensive treatment (beta blockers, inhibitors of angiotensin-converting enzyme and AT1 receptors) and correction of anaemia. They suppose that many patients do not get complete antihypertensive treatment to decrease cardiovascular risk. We did not confirm any relation between blood pressures during whole monitoring (day and night) and left ventricular end diastolic diameter. This result can indicate that blood pressure is not linearly related to volume, but there exists a multifactorial influence (uremic toxins, anaemia, blood pressure, myocardial ischemia, valvular disease and etc.) (15).

In our retrospective study we did not show any significant correlation of blood pressure and ejection fraction. We can explain this finding by multifactorial relationship, because many patients suffer from severe organic heart disease (16).

Because of positive relation between ratio of peak early late diastolic filling velocity and blood pressure we can deduce a following hypothesis „as blood pressure rises the tendancy to restrictive filling is increasing“. This hypothesis would need to be tested with adequate range designed study. Surprisingly, being consistent with Facchin et al (17), most of diastolic parameters were not related to blood pressure. Explanation can be an impact of many factors (except those mentioned in the upper part of discussion, age, heart rate, circulating volume and others) to evaluate diastolic parameters. Limitation of our study is the fact that tissue Doppler parameters were not evaluated in relationship with blood pressure due to retrospective character of our work.

An interesting finding of our study is, that diastolic blood pressure (systolic not) significantly decreased in the night. This fact influenced significantly mean arterial blood pressure and marginally the pulse pressure. Late redistribution of fluid into extravascular compartment during 24 hours after the haemodialysis occured (18).

Cardiovascular morbidity and mortality among chronic haemodialysis patients is high (19). This well-known fact is confirmed also in our retrospective study because 12 patients (24 %) died during the follow up.

Conclusion

We found out an important 24-hour blood pressure impact on left ventricular relative wall thickness and left ventricular mass index. Left ventricular ejection fraction, left ventricular enddiastolic diameter and left atrial size were not related to 24-hour blood pres-

sure impact. From all diastolic parameters the strongest association was found between systolic blood pressure in all three phases and ratio of peak early to late diastolic filling velocity.

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